AN INSTRUMENT FOR MEASURING HORIZONTAL TOOTH MOBILITY,

AEROSPACE MEDICAL DIV BROOKS AFB TX

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FOREWORD

This report was prepared in the Dental Sciences Division by —

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ABSTRACT

An instrument for measuring horizontal tooth mobility has been developed for use in clinical practice and in research. The instrument consists of a multijointed carrying vehicle which supports and allows proper positioning of a mechanical dial test indicator with a recording point. The carrying vehicle is attached to the dental arches by a clutch with an extraoral female attachment. Analysis of the data obtained with the instrument showed that good reproducibility is obtained when measurements are made by trained investigators. Reproducibility was good on a group of subjects ranging widely as to periodontal status and age. It was not affected by removal and recementing of the apparatus. The mobility of a complement of 28 teeth can be measured in thirty-five to forty minutes.

This technical documentary report has been reviewed and is approved.

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1. INTRODUCTION

The first clinically detectable sign of periodontal disease is frequently an increase in tooth mobility. Increased tooth mobility is an important factor in determining the prognosis and indicated therapy of individual teeth and arches that are periodontally involved. Clinically, we consider elimination of abnormal mobility patterns as an objective sign of arrest of disease and a return to periodontal health. Consequently, methods devised for measuring mobility have ranged from the clinical assessment employed by Miller (1), to mechanical (2-5), vibratory (6,7), and electronic devices (8-11).

The two measuring devices developed by Muhlemann (4,5) have been employed in a number of investigations (12-16). The macroperiodontometer consists of a dial indicator attached to an impression tray with the point of the indicator at right angles to the labial or buccal surface being measured. The teeth are deflected palatally or labially with a known force and the deflection is measured in hundredths of millimeters. Reproducibility of measurements made with the macroperiodontometer is high (17). The usefulness of the instrument is limited, however, because it is designed primarily for use in the maxillary incisor, cuspid, and first premolar areas.

The microperiodontometer is a small-dial test indicator held in position by means of a rubber dam clamp attached to a tooth on the opposing side of the arch. Muhlemann (18) states that correct use of the instrument is difficult to learn, the technic is time-consuming, and results obtained are less reproducible than with the macroperiodontometer.

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Goldberg (11) has reported on an electronic device for measurement of horizontal tooth mobility of maxillary and mandibular anterior teeth. Picton (8) and Parfitt (9,10) have reported on electronic systems to measure axial tooth mobility. It is apparent that for clinical research there is need for an instrument that will allow assessment of horizontal tooth mobility in all areas of the mouth with reasonable speed.

The instrumentation described here was developed by the investigators with the help of personnel of the Instrument Shop, USAF School of Aerospace Medicine. It was designed to allow measurement of tooth mobility in all areas of the dental arches.

2. THE PROTOTYPE INSTRUMENT

The original instrument (fig. 1) consists of a multijointed carrying vehicle supporting a dial test indicator (Lufkin) with a 1½-inch recording point which can be rotated over 180° in a horizontal plane. The dial indicator is divided in 0.0005-inch graduations, and readings as small as 0.0001 inch can be made. A clutch, with an extraoral female receptacle, permits attachment of the instrument to the dental arches. (*Note:* If the metric system of measurement is preferred, the dial test indicator can be graduated in hundredths of millimeters.)

The tubing and discs in the carrying vehicle are fabricated of hollow stainless steel while the knurled adjustment knobs are aluminum. A Gramm forcemeter, modified by lengthening the force arm $1^1/_{16}$ inches and recalibrating the dial, is employed to transmit force to the teeth.

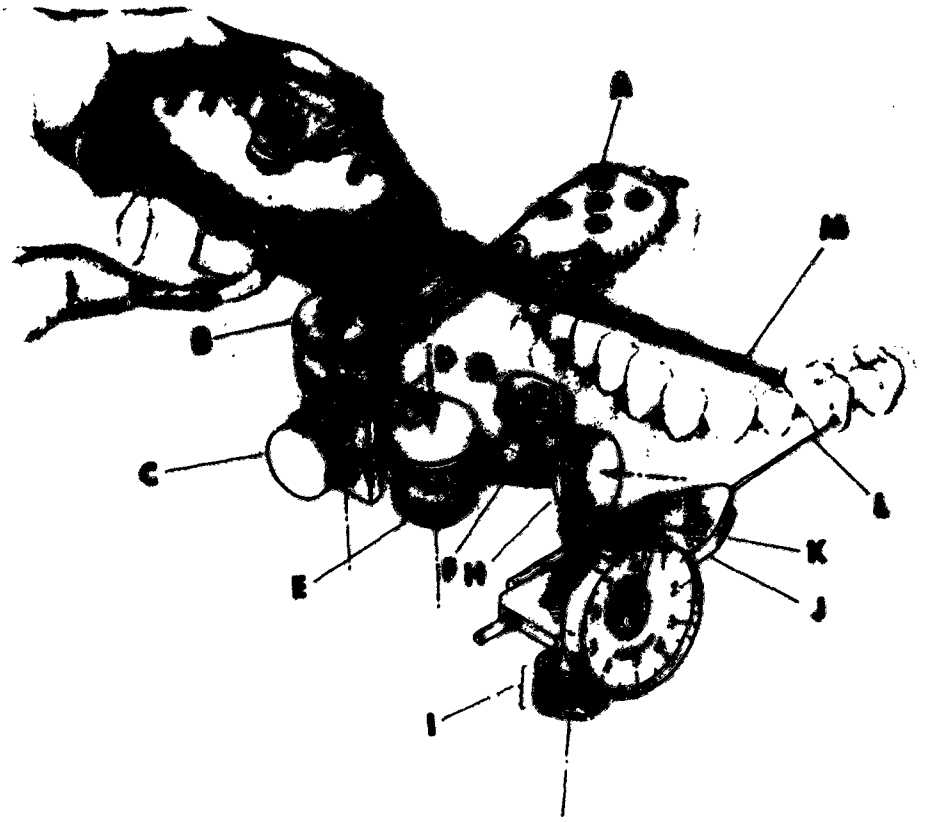

FIGURE 1

The prototype instrument.

3. TECHNIC

The clutch *A* is cemented in a posterior segment with quick setting stone. A rubber bite block is placed over the clutch for the subject to close his teeth into. The male attachment of the carrying vehicle is then placed in the female attachment on the front of the clutch *A* and is held at the desired vertical height by tightening the knurled knob *C*. The remaining joints are not tightened until the recording point is in approximate position on the tooth where movement is to be recorded. The knurled knob *B* is first tightened to prevent horizontal movement of the arm *D*. Tightening knob *E* maintains the arm *F* in the desired horizontal position. The friction joint *H* permits vertical adjustment of the recording point at the desired height on the tooth and is controlled by tightening knob *G*. The knobs at *I* control a universal gimbal joint. The upper knob at *I* allows the entire dial test indicator *J* with the recording point *L* to be moved to or from the mouth. The lower knob at *I*, by permitting the dial test indicator and recording point to rotate on a 360° horizontal plane, allows a large range of adjustment. The click stop *K* on the dial test indicator *J* controls the direction in which movement is recorded. In practice the recording point is placed on the tooth in approximately the middle of its range (0.080 inch).

Tooth movement is determined by applying a force of 500 gm. from (1) the buccal and (2) the lingual surface and adding the two

measurements. This is accomplished twice for each tooth, and the average of the two measurements gives the mobility of the particular tooth. With one cementation, the posterior teeth on the opposite side of the arch are measured, plus the three anterior teeth nearest the clutch. This sequence allows paralleling the recording arm and the tooth to be measured.

To remove the carrying vehicle, the knurled knob *C* is loosened and the male attachment removed from the female attachment of the clutch. The clutch is removed from the teeth by grooving the dental stone beneath the anterior lip of the clutch and rotating a thin-bladed instrument occlusally in the prepared groove. Any stone remaining about the teeth is easily removed with a sharp instrument.

4. FIELD TESTING AND MODIFICATION

The value of the prototype instrument was limited because of three problems: (1) the bearing surface areas of the friction joints proved to be so small as to allow some slippage

FIGURE 2

The modified instrument showing placement to measure mobility of the upper right first molar. Force is applied to the palatal surface with the modified forcemeter.

in the instrument; (2) it was difficult to place the recording point of the instrument parallel to the buccal surfaces of all teeth; and (3) the stainless steel recording point tended to skid on smooth surfaces.

To overcome these difficulties the instrument was remade — constructed of stainless steel throughout. The friction joints were redesigned as positive lock adjustment joints with serrated surfaces closing into bronze bushings. The clutch *A* was redesigned and a positive lock adjustment joint placed behind the female receptacle. This allowed the carrying vehicle to rotate and permitted placement of the dial test indicator at right angles to the tooth being measured and the recording point parallel to the facial or buccal surfaces. The addition of this joint facilitated the assessment of maxillary and mandibular molar tooth mobility (fig. 2). The recording point of the dial test indicator (figs. 2 and 3) was coated with a layer of 0.230 mesh diamond grit which eliminated any tendency to "skid."

5. INTEREXAMINER REPRODUCIBILITY

To determine reproducibility of measurements made with the instrument, tooth mobility of seventeen subjects ranging in age from 17 to 54 years was assessed at two different sittings. The time lapse between sittings was approximately thirty minutes. The periodontal status of the 425 teeth sampled ranged from a high degree of health to advanced disease.

The two investigators independently tested the mobility of the subjects' teeth at each sitting. This gave a total of four measurements of each tooth evaluated. The carrying vehicle was removed after each measurement and recemented by the dentist making the next measurement. Order of measurement (first or second) within a sitting was randomly assigned to the two investigators.

FIGURE 3

Instrument placement to measure mobility of lower left lateral incisor.

Although all the subjects had an intact or nearly intact dentition, the number of teeth measured per subject varied from 8 to 28. This variation was due to the amount of time the investigators could allocate to the subject. Since the mobility of various types of teeth varies, each tooth was analyzed separately. Total tooth mobility readings in ten-thousandths of an inch were analyzed by an analysis of variance technic. No differences were found between the investigators in terms of mean mobility measurements for any of the teeth tested (table I). Second sitting means are consistently higher than first sitting means for all teeth sampled (table II); in several instances the increases were statistically significant ($P < .05$). These temporary increases are logical since a series of measurements involves the alternate application of 500 gm. of force to the buccal and lingual surfaces of the teeth.

It can be seen (table I) that the difference between tooth mobility means for each dentist is quite small. The subjects used in this analysis presented a wide range as to age and periodontal status. Removing and recementing the instrument did not affect the reproducibility of results. It must be emphasized that these results were obtained by two investigators well versed in the use of the measuring system.

TABLE I

Tooth mobility tested by two investigators

Tooth No.	N	Dentist 1 ($\bar{X}_1$)	Dentist 2 ($\bar{X}_2$)	d.f.*	S. E. of difference†
2	30	31.0	31.2	14	.19
3	28	23.9	24.0	13	.25
4	30	32.3	32.5	14	.17
5	30	29.3	29.5	14	.20
6	30	26.7	27.0	14	.22
7	32	46.1	46.3	15	.19
8	32	50.3	50.2	15	.21
9	32	51.4	51.4	15	.20
10	30	48.9	48.8	14	.20
11	30	25.8	25.6	14	.18
12	32	27.5	27.5	15	.24
13	32	29.5	29.5	15	.18
14	32	22.1	21.9	15	.19
15	32	31.2	30.8	15	.20
18	30	32.6	32.3	14	.20
19	28	22.8	22.6	13	.13
20	30	24.7	24.7	14	.12
21	30	22.0	22.1	14	.17
22	30	25.3	25.2	14	.20
23	30	42.3	42.4	14	.19
24	30	51.6	51.2	14	.21
25	30	50.8	50.7	14	.22
26	30	41.5	41.6	14	.22
27	30	26.4	26.4	14	.19
28	30	21.3	21.1	14	.14
29	30	24.5	24.3	14	.17
30	30	23.3	23.4	14	.20
31	30	32.4	32.5	14	.19

Figures represent mean values (inches $\times 10^{-4}$) found by dentist 1 and dentist 2.

*Degrees of freedom are one less than the number of subjects.

†$t = \dfrac{\bar{X}_2 - \bar{X}_1}{\text{S.E. of difference}}$

TABLE II

Tooth mobility according to two sittings

Tooth No.	N	First sitting ($\bar{X}_1$)	Second sitting ($\bar{X}_2$)	d.f.*	S. E. of difference†
2	30	31.1	31.1	14	.62
3‡	28	22.9	25.0	13	.82
4	30	31.8	33.0	14	.95
5	30	28.8	30.0	14	.75
6	30	26.8	26.9	14	.82
7‡	32	45.0	47.5	15	.80
8‡	32	48.9	51.7	15	.61
9	32	50.8	52.1	15	.75
10	30	47.9	49.9	14	1.19
11‡	30	24.7	26.7	14	.83
12	32	26.9	28.1	15	.73
13	32	29.0	30.0	15	.80
14	32	21.6	22.4	15	.57
15	32	30.1	32.0	15	.99
18	30	31.8	33.1	14	.74
19‡	28	21.6	23.9	13	.76
20‡	30	23.8	25.6	14	.60
21‡	30	21.2	22.9	14	.40
22	30	25.1	25.5	14	.60
23‡	30	41.3	43.5	14	.49
24‡	30	50.4	52.5	14	.76
25‡	30	50.0	51.5	14	.56
26‡	30	40.2	42.9	14	.69
27	30	26.0	26.8	14	.50
28	30	20.6	21.8	14	.56
29	30	24.0	24.8	14	.58
30	30	23.2	23.5	14	.54
31	30	32.1	32.8	14	.70

Values are means expressed in inches / 10^{-4}.

* Degrees of freedom are one less than the number of subjects.

† $t = \dfrac{\bar{X}_2 - \bar{X}_1}{\text{S.E. of difference}}$

‡ Difference between sitting means is statistically significant ($P < .05$).

6. DISCUSSION

The development of objective measuring systems is a necessity for clinical research. Moreover, the more precise a system becomes, the more stringent the rules for its use. This applies to the instrument described above.

The following procedures must be observed to secure reliable results. The recording point must be positioned parallel or nearly parallel to the labial or buccal surface of the tooth being measured, with the body of the dial test indicator at right angles to the tooth. Measurements must be made at the same vertical height on the tooth. In practice, the investigators carry out all measurements on incisor and cuspid teeth at a point 2 to 3 mm. from the incisal edge. Premolar and molar teeth are measured at a point 4 to 5 mm. from the tip of the buccal cusp. It has been determined that a variation of $= 1$ mm. has no appreciable effect on readings. Diagnostic casts are made for the patients requiring extensive periodontic or prosthodontic treatment, and the spot for placement of the recording point is marked on the cast teeth before mobility measurements are accomplished. The diagnostic casts are then used as a guide for placement of the recording

point at all subsequent assessments. The mobility of a complement of 28 teeth can be measured in thirty-five to forty minutes.

The face of the dial indicator is movable, allowing the zero point to be coincided with the pointer before carrying out measurements. This is a useful check, as any drifting past the zero point on releasing the force makes validity of the reading questionable and such a reading is discarded.

The angle at which force is applied to the tooth must also be controlled. The force is applied at right angles to the surface and at the midpoint of the tooth mesiodistally. The 500-gm. force is applied to the tooth for a minimal period. Maintaining the force against the tooth for a longer period of time results in a progressive increase in the mobility reading.

Reproducibility of measurements obtained with the system described has been compared with reproducibility obtained employing the macroperiodontometer developed by Muhlemann. The study was carried out on maxillary incisor teeth. It was determined that reproducibility was at the least equal to that obtained with the macroperiodontometer.

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